TITLE OF THE INVENTION

VALVE ASSEMBLY FOR RECIPROCATING COMPRESSORS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 2003-77227, filed November 3, 2003 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates, in general, to reciprocating compressors and, more particularly, to a valve assembly for the reciprocating compressors, elements of which are easily assembled into a single body, and which reduces operational impact and noise caused by an operation of a reed valve, thus allowing a silent operation of the reciprocating compressors.

Description of the Related Art

Generally, a conventional reciprocating compressor includes a plurality of elements which are a stator, a rotor, a crankshaft, a cylinder, a piston and a cylinder head. The above-mentioned elements are hermetically housed in a hermetic casing. The stator and the rotor are installed in the hermetic casing such that the stator is immobile, while the rotor is rotatable. The crankshaft axially penetrates through the rotor to rotate along with the rotor in response to an electromagnetic action between the stator and the rotor when the compressor is turned on as a result of electricity being supplied. The cylinder defines a chamber therein to draw and then compress a gas in the chamber, while the piston is received in the cylinder so as to execute a rectilinear reciprocating motion in the cylinder, in response to a rotation of the crankshaft. The cylinder head covers a top of the cylinder. During an operation of the conventional reciprocating compressor, the piston rectilinearly reciprocates in the cylinder in response to the rotation of the crankshaft, thus drawing a gas into

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the cylinder inside the hermetic casing, and then compressing the gas, prior to releasing the compressed gas under high pressure from the cylinder to an outside of the hermetic casing. The conventional reciprocating compressor having the above-mentioned construction is preferably used in a refrigeration system, such as a refrigerator or an air conditioner, so as to compress a gas refrigerant under low pressure to make the gas refrigerant under high pressure.

In the conventional reciprocating compressor, a valve assembly is interposed between the cylinder and the cylinder head so as to control both low-pressure gas suction into the cylinder inside the hermetic casing and high-pressure gas exhaust from the cylinder to the outside of the hermetic casing, during the operation of the reciprocating compressor.

A conventional valve assembly for reciprocating compressors includes an exhaust valve unit having a reed valve, a stopper and a keeper. The reed valve controls the gas exhaust from the cylinder to the outside of the hermetic casing, while the stopper limits an opening ratio of the reed valve within a predetermined range. The keeper supports the stopper. The reed valve, the stopper and the keeper of the exhaust valve unit are sequentially assembled on an exhaust hole plate which has both a suction hole and an exhaust hole. The exhaust hole plate having the exhaust valve unit is set together with a suction valve plate integrally having a suction valve, at a position between the cylinder and the cylinder head by use of a plurality of locking members, such as bolts.

When the piston is moved from a lower dead center to an upper dead center in the cylinder, the gas is compressed in the cylinder. A pressure of the compressed gas is thus applied to the exhaust hole, so that a free end of the reed valve is elastically bent along with the stopper toward the cylinder head, thereby opening the exhaust hole. The compressed gas under high pressure is thus released from the cylinder to the outside of the hermetic casing through both the cylinder head and the open exhaust hole. When the piston is moved from the upper dead center to the lower dead center in the cylinder, the reed valve elastically closes the exhaust hole, due to a restoring force of both the stopper and the reed valve, and, at the same time, the suction valve of the suction valve plate is opened to draw the gas under low pressure into the

cylinder through both the open suction hole and the cylinder head.

However, the conventional valve assembly for reciprocating compressors is problematic, as follows. In the conventional valve assembly for the reciprocating compressors, the reed valve to control the exhaust hole, the stopper to limit the opening ratio of the reed valve within the predetermined range, and the keeper to support the stopper are separately produced, and are sequentially assembled on the exhaust hole plate. Therefore, the reed valve, the stopper and the keeper must be sequentially assembled on the exhaust hole plate, before the exhaust hole plate is set between the cylinder and the cylinder head by use of the plurality of bolts. Thus, excessive time is consumed while assembling the reed valve, the stopper and the keeper into the valve assembly.

SUMMARY OF THE INVENTION

Accordingly, it is an aspect of the present invention to provide a valve assembly for reciprocating compressors, elements of which are easily assembled into a single body.

It is another aspect of the present invention to provide a valve assembly for reciprocating compressors, which reduces operational impact and noise caused by an operation of a reed valve, thus allowing a silent operation of the reciprocating compressors.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

The above and/or other aspects are achieved by providing a valve assembly for reciprocating compressors having a cylinder, a cylinder head and a valve assembly arranged between the cylinder and cylinder head, the valve assembly including: an exhaust hole plate having an exhaust hole communicating with the cylinder; a reed valve plate having a reed valve to open or close the exhaust hole of the exhaust hole plate, the reed valve being integrally formed in the reed valve plate by cutting a predetermined portion of the reed valve plate, with a junction end and a free end formed at first and

second ends of the reed valve, respectively; a stopper plate having a stopper to limit an opening ratio of the reed valve within a predetermined range, the stopper being integrally formed in the stopper plate by cutting a predetermined portion of the stopper plate, with a junction end and a free end formed at first and second ends of the stopper, respectively, the stopper being bent toward the cylinder head at a predetermined angle of inclination relative to the stopper plate, with an elastic support part provided at the free end of the stopper so as to be elastically supported by a pressure unit of the cylinder head and provide an elastic force to the stopper; and the pressure unit provided on a surface of the cylinder head so as to support the stopper and allow the stopper to pre-pressurize the reed valve.

The elastic support part may be provided by bending the free end of the stopper toward the cylinder head at a predetermined angle of inclination.

The pressure unit may include: a first pressure projection projected from the cylinder head at a position corresponding to the junction end of the stopper, thus compressing the junction end of the stopper; a second pressure projection projected from the cylinder head at a position corresponding to the elastic support part of the stopper, thus compressing the elastic support part of the stopper; and a third pressure projection projected from the cylinder head at a position corresponding to an intermediate point of the stopper between the junction end and the free end of the stopper, thus compressing the intermediate point of the stopper.

The second pressure projection may be slightly longer than the first pressure projection, and the third pressure projection may be slightly shorter than the first pressure projection, so that the first, second and third pressure projections support the stopper while bending the stopper into a bow shape at a position between the cylinder head and the exhaust hole plate, and the free end of the reed valve is pre-pressurized by the elastic support part of the stopper which is compressed by the second pressure projection.

The third pressure projection may be eccentrically positioned between the first and second pressure projections, and the exhaust hole may be formed on the exhaust hole plate at a position corresponding to the third pressure

projection.

The third pressure projection may be positioned to be eccentric toward the second pressure projection.

The valve assembly may further include: a depression formed on a surface of the exhaust hole plate at a position around the exhaust hole, so that the reed valve closes the exhaust hole while a part of the reed valve comes into contact with areas of the exhaust hole plate around the exhaust hole and the depression.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a longitudinal sectioned view of a reciprocating compressor having a valve assembly, according to an embodiment of the present invention;

FIG. 2 is an exploded perspective view of the valve assembly of FIG. 1;

FIG. 3 is a top perspective view of an exhaust hole plate included in the valve assembly of FIG. 2;

FIG. 4 is a top perspective view of a reed valve plate included in the valve assembly of FIG. 2;

FIG. 5 is a top perspective view of a stopper plate included in the valve assembly of FIG. 2;

FIG. 6 is a bottom perspective view of a cylinder head which is included in the reciprocating compressor of FIG. 1, and is assembled with the valve assembly of FIG. 2;

FIG. 7 is a sectional view taken along the line A-A of FIG. 2, when the reed valve closes an exhaust hole; and

FIG. 8 is a sectional view taken along the line A-A of FIG. 2, when the reed valve opens the exhaust hole.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

FIG. 1 is a longitudinal sectioned view of a reciprocating compressor having a valve assembly 20, according to an embodiment of the present invention. As shown in FIG. 1, the reciprocating compressor according to the embodiment of the present invention includes a plurality of elements which are a stator 1, a rotor 2, a crankshaft 3, a cylinder 4, a piston 6 and a cylinder head 7. The above-mentioned elements of the reciprocating compressor are hermetically housed in a hermetic casing 10. The stator 1 and the rotor 2 are installed in the hermetic casing 10, such that the stator 1 is immobile, while the rotor 2 is rotatable. The crankshaft 3 is axially inserted into the rotor 2 to rotate along with the rotor 2. The cylinder 4 defines a compression chamber therein. The piston 6 is received in the cylinder 4, and is coupled to the crankshaft 3 via a connecting rod 5. The cylinder head 7 covers a top of the cylinder 4.

A gas suction pipe 8 and a gas exhaust pipe (not shown) pass through the hermetic casing 10, and are mounted to the cylinder head 7, so that a gas is drawn into the cylinder 4 through the gas suction pipe 8. The gas is then compressed in the cylinder 4, and is released from the cylinder 4 to an outside of the hermetic casing 10 through the gas exhaust pipe. The reciprocating compressor further includes the valve assembly 20 which is interposed between the cylinder 4 and the cylinder head 7 so as to control both gas suction into the cylinder 4 inside the hermetic casing 10 and gas exhaust from the cylinder 4 to the outside of the hermetic casing 10 during an operation of the reciprocating compressor.

FIG. 2 is an exploded perspective view showing a construction of the valve assembly 20, according to the present invention. As shown in FIG. 2, the valve assembly 20 includes an exhaust hole plate 30 having an exhaust hole 31,

a reed valve plate 40 having a reed valve 41, and a stopper plate 50 having a stopper 51. In the valve assembly 20, the exhaust hole plate 30, the reed valve plate 40 and the stopper plate 50 are sequentially arranged between the cylinder 4 and the cylinder head 7.

The valve assembly 20 also has a gasket 60 and a suction valve plate (not shown). The gasket 60 is closely interposed between the cylinder head 7 and the stopper plate 50 so as to prevent a gas leakage from a junction of the cylinder head 7 and the stopper plate 50. The suction valve plate (not shown) having a suction valve is arranged under the exhaust hole plate 30, so that the suction valve of the suction valve plate controls a suction hole 32 provided on the exhaust hole plate 30.

The present invention is characterized in that the construction of both the reed valve and the stopper is improved to accomplish the aspects of the invention, so that the suction valve plate is not shown in the accompanying drawings, and further explanation for the suction valve plate is not deemed necessary.

In the valve assembly 20, all the exhaust hole plate 30, reed valve plate 40, stopper plate 50, gasket 60 and the cylinder head 7 have rectangular designs which are chamfered or rounded at corners thereof. The exhaust hole plate 30, reed valve plate 40, stopper plate 50 and the gasket 60 are provided with a plurality of locking holes 35, 45, 55 and 65 at corners thereof. Therefore, the exhaust hole plate 30, reed valve plate 40, stopper plate 50 and the gasket 60 are assembled with each other when the cylinder head 7 is fastened to the cylinder 4 by use of a plurality of bolts 26. In such a case, the bolts 26 are initially inserted into locking holes 25 provided at corners of the cylinder head 7, and sequentially pass through the locking holes 65, 55, 45 and 35 of the gasket 60, stopper plate 50, reed valve plate 40 and the exhaust hole plate 30, prior to being tightened to the cylinder 4.

To compress the stopper 51 at several points and thereby to support the stopper 51 while bending the stopper 51 into a predetermined shape so as to allow the stopper 51 to pre-pressurize a free end 43 of the reed valve 41, the valve assembly 20 has a pressure unit 70 which is provided on a surface of the

cylinder head 7. The construction of the reed valve 41, stopper 51 and the pressure unit 70 will be described in detail herein below, with reference to FIGS. 3 to 6.

FIGS. 3 to 5 are top perspective views of the exhaust hole plate 30, reed valve plate 40 and the stopper plate 50 of the valve assembly 20 of FIG. 2, respectively. FIG. 6 is a bottom perspective view of the cylinder head 7 which is assembled with the valve assembly 20 of FIG. 2.

As shown in FIG. 3, the exhaust hole plate 30 is a flat plate having a predetermined thickness, with one locking hole 35 formed at each of the rounded corners of the exhaust hole plate 30. The exhaust hole 31 and the suction hole 32 are formed in the exhaust hole plate 30, so that the gas is drawn into the cylinder 4 through the suction hole 32 so as to be compressed in the cylinder 4, prior to being discharged from the cylinder 4 to the outside of the hermetic casing 10 through the exhaust hole 31.

The exhaust hole plate 30 further includes a depression 33 which is formed on a surface of the exhaust hole plate 30 at a position around the exhaust hole 31. The depression 33 has a size slightly smaller than a size of the reed valve 41 of the reed valve plate 40. Therefore, when the reed valve 41 closes the exhaust hole 31, only a part of the reed valve 41 comes into contact with areas of the exhaust hole plate 30 around the exhaust hole 31 and the depression 33. Therefore, a contact area between the reed valve 41 and the surface of the exhaust hole plate 30 is reduced, when the reed valve 41 closes the exhaust hole 31. The operational noise of the reed valve 41 is thus reduced.

As shown in FIG. 4, the reed valve plate 40 is a flat plate which is remarkably thinner than the exhaust hole plate 30. One locking hole 45 is formed at each of the chamfered corners of the reed valve plate 40. The reed valve 41 is provided in the reed valve plate 40 at a position corresponding to the depression 33 including the exhaust hole 31 of the exhaust hole plate 30, thus opening or closing the exhaust hole 31.

The reed valve 41 is integrally formed in the reed valve plate 40 by cutting a predetermined portion of the reed valve plate 40 along a U-shaped line. The reed valve 41 is thus integrated with a remaining part of the reed valve plate

40 at a first end thereof at which the reed valve 41 is not cut, so that the first end of the reed valve 41 forms a junction end 42. A second end of the reed valve 41, at which the reed valve 41 is separated from the remaining part of the reed valve plate 40, forms the free end 43. The reed valve 41 is elastically bent at the free end 43 so as to open or close the exhaust hole 31.

As shown in FIG. 5, the stopper plate 50 is a flat plate which is remarkably thinner than the exhaust hole plate 30, in the same manner as that described for the reed valve plate 40. One locking hole 55 is formed at each of the chamfered corners of the stopper plate 50. The stopper 51, having a size corresponding to the reed valve 41, is provided in the stopper plate 50 at a position corresponding to the reed valve 41. The stopper 51 limits an opening ratio of the reed valve 41 within a predetermined range, while pre-pressurizing the free end 43 of the reed valve 41.

In the same manner as that described for the reed valve 41, the stopper 51 is integrally formed in the stopper plate 50 by cutting a predetermined portion of the stopper plate 50 along a U-shaped line. The stopper 51 is thus integrated with a remaining part of the stopper plate 50 at a first end thereof at which the stopper 51 is not cut, and the first end of the stopper 51 forms a junction end 52. A second end of the stopper 51, at which the stopper 51 is separated from the remaining part of the stopper 50, forms a free end 53. The free end 53 of the stopper 51 limits the opening ratio of the reed valve 41 within the predetermined range.

The stopper 51 is also bent at the junction end 52 at an angle θ of inclination relative to the remaining part of the stopper plate 50, so that the stopper 51 is raised toward the cylinder head 7. The stopper 51 is bent again at the free end 53 thereof at an angle ω of inclination relative to a remaining part of the stopper 51, so that the free end 53 of the stopper 51 is further raised toward the cylinder head 7 and forms an elastic support part 54. Due to the elastic support part 54, the stopper 51 has a sufficient elastic force capable of efficiently pre-pressurizing the reed valve 41. In the present invention, the angles θ and ω of inclination of the stopper 51 are preferably set to 90° or less.

When the stopper plate 50 is set in the valve assembly 20 at a

predetermined position between the cylinder head 7 and the exhaust hole plate 30, the stopper 51 is compressed at several points thereof by the pressure unit 70 of the cylinder head 7, so that the stopper 51 is supported while being smoothly bent into a bow shape.

As shown in FIG. 6, the pressure unit 70 is provided on the lower surface of the cylinder head 7 having one locking hole 25 at each of the rounded corners thereof. The pressure unit 70 compresses the raised stopper 51 of the stopper plate 50 at the several points to support the stopper 51 while bending the stopper 51 into the bow shape.

The pressure unit 70 includes first, second and third pressure projections 71, 72 and 73. The first pressure projection 71 is formed in the cylinder head 7 at a position corresponding to the junction end 52 of the stopper 51. The second pressure projection 72 is formed in the cylinder head 7 at a position corresponding to the elastic support part 54 of the stopper 51. The third pressure projection 73 is formed in the cylinder head 7 at a position corresponding to an intermediate point of the stopper 51 between the junction end 52 and the free end 53. The arrangement of the first, second and third pressure projections 71, 72 and 73 in the cylinder head 7 will be described in detail herein below, with reference to FIGS. 7 and 8.

FIGS. 7 and 8 are sectional views taken along the line A-A of FIG. 2, when the reed valve 41 of the reed valve plate 40 closes and opens the exhaust hole 31 of the exhaust hole plate 30, respectively.

As shown in FIG. 7, the first and second pressure projections 71 and 72 are projected from the lower surface 7a of the cylinder head 7 toward the cylinder 4, so that pressure surfaces of the first and second pressure projections 71 and 72 are embossed on the lower surface 7a. In the above state, the second pressure projection 72 is slightly longer than the first pressure projection 71. The third pressure projection 73 is projected in a depression formed on the lower surface 7a of the cylinder head 7, so that a pressure surface of the third pressure projection 73 does not reach a level of the lower surface 7a. That is, the third pressure projection 73 is slightly shorter than the first pressure projection 71. Therefore, the first, second and third pressure projections 71, 72

and 73 of the pressure unit 70 compress the junction end 52, elastic support part 54 and the intermediate point between the junction and free ends 52 and 53 of the stopper 51, respectively, thus supporting the stopper 51 while bending the stopper 51 into the bow shape.

In other words, the junction end 52 of the stopper 51, which is connected to the remaining part of the stopper plate 50, is compressed by the first pressure projection 71, thus being secured without being relocated. The elastic support part 54 of the stopper 51 is slightly compressed by the second pressure projection 72, such that the elastic support part 54 is positioned to be movable toward the junction end 52 through a gap between the cylinder head 7 and the exhaust hole plate 30. The intermediate point of the stopper 51 between the junction and free ends 52 and 53 is slightly compressed by the third pressure projection 73 which does not reach the level of the lower surface 7a of the cylinder head 7, so that the stopper 51 is supported by the first, second and third pressure projections 71, 72 and 73 while being bent into the bow shape.

Because the stopper 51 is supported at three points by the first, second and third pressure projections 71, 72 and 73 of the pressure unit 70 while the stopper 51 is bent into the bow shape as described above, the free end 43 of the reed valve 41 which is placed between the stopper 51 and the exhaust hole plate 30 is pre-pressurized by the elastic support part 53 of the stopper 51 in a direction toward the exhaust hole plate 30, under the condition that the free end 43 of the reed valve 41 is movable toward the junction end 42.

In the valve assembly, the first and third pressure projections 71 and 73 are spaced apart from each other by a distance L1 which is slightly longer than a distance L2 between the second and third pressure projections 72 and 73. In other words, the third pressure projection 73 is eccentrically positioned between the first and second pressure projections 71 and 72, such that the third pressure projection 73 is slightly closer to the second pressure projection 72 than the first pressure projection 71. That is, the third pressure projection 73 which is placed between the first and second pressure projections 71 and 72, is slightly eccentric toward the second pressure projection 72. Due to the specific arrangement of the first, second and third pressure projections 71, 72 and 73,

the reed valve 41 closes or opens the exhaust hole 31 of the exhaust hole plate 30 at a position slightly closer to the free end 43 than the junction end 42 of the reed valve 41. Therefore, the reed valve 41 accomplishes less deformation during an operation of the reed valve 41, in comparison with a conventional valve assembly in which the reed valve closes or opens the exhaust hole at a central position of the reed valve. The reed valve 41 of the present invention thus reduces impact and noise during the operation thereof. Furthermore, the reed valve 41 smoothly opens or closes the exhaust hole 31.

The valve assembly 20 for reciprocating compressors according to the present invention having the above-mentioned construction is operated, as follows. During an operation of the reciprocating compressor in which the piston 6 moves to a lower dead center in the cylinder 4, the reed valve 41 is pre-pressurized by the elastic support part 54 of the stopper 51 in a direction toward the exhaust hole plate 30, as shown in FIG. 7. The reed valve 41 in the above state thus closes the exhaust hole 31.

However, when the piston 6 moves from the lower dead center to an upper dead center in the cylinder 4, a pressure of the gas compressed in the cylinder 4 increases to become higher than the pressure applied to the reed valve 41 from the stopper 51 which has pre-pressurized the reed valve 41. Therefore, a part of the reed valve 41, which corresponds to the exhaust hole 31, moves toward the cylinder head 7 as shown in FIG. 8, and, at the same time, the free end 43 of the reed valve 41 moves toward the junction end 42 of the reed valve 41. The exhaust hole 31 is thus open.

During the operation to open the exhaust hole 31, the elastic support part 54 of the stopper 51, which has pre-pressurized the free end 43 of the reed valve 41, slightly moves toward the junction end 52 of the stopper 51 through the gap between the third pressure projection 73 of the cylinder head 7 and the exhaust hole plate 30, thus allowing the exhaust hole 31 to be open.

When the piston 6 moves again from the upper dead center to the lower dead center in the cylinder 4, both the stopper 51 and the reed valve 41 restore original shapes thereof. The reed valve 41 thus closes the exhaust hole 31 again, as shown in FIG. 7.

As apparent from the above description, the present invention provides a valve assembly for reciprocating compressors, elements of which are easily assembled into a single body. In the valve assembly according to the present invention, a reed valve and a stopper are respectively integrated with a reed valve plate and a stopper plate which are easily assembled with a cylinder together with a cylinder head by use of a plurality of bolts. The reed valve and the stopper are thus easily assembled into the valve assembly, thus conserving time and reducing costs while producing the reciprocating compressors.

In the valve assembly for reciprocating compressors according to the present invention, the stopper is compressed at several points thereof by a pressure unit provided on a lower surface of the cylinder head, so that the stopper is supported while being smoothly bent into a bow shape, and pre-pressurizes a free end of the reed valve. Furthermore, the reed valve opens or closes an exhaust hole while a part of the reed valve is in contact with the exhaust hole at an intermediate portion between the free end and a junction end of the reed valve. Therefore, the valve assembly remarkably reduces impact and noise caused by an operation of the reed valve while opening or closing the exhaust hole. Furthermore, the reed valve does not vibrate at the free end thereof, thus improving the operational performance of the reciprocating compressors.

Furthermore, in the valve assembly of the present invention, the stopper has an elastic support part at a portion around a free end thereof, thus the stopper has a sufficient elastic force capable of efficiently pre-pressurizing the reed valve. Therefore, the valve assembly reliably prevents the reed valve from being undesirably open when a gas refrigerant is not completely compressed in a compression chamber of a cylinder, thus the valve assembly improves operational reliability of the reciprocating compressors.

Although a preferred embodiment of the present invention has been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.